# Prologue

Hello,

If you are reading this then you are about to embark on a wonderful exploration into generalized sciences with your cub scout den, patrol, or pack. I have put together this document to outline what you can cover, who you can reach out to, and how to make it fun. I hope your experience is a success and that the youth come out of this with a newfound love for science and the tools we use to explain the world we live in and beyond.

If you are new to the STEM/NOVA program with BSA, let me just cover some of the basics. STEM stands for Science, Technology, Engineering, and Mathematics. They are the core components in logic and deductive reasoning in our world today, a skill that has been lost by most. For generations the US was the leader in many of these fields, but we have begun to stray from this path and it only hurts us as a nation. Children, myself included, were raised to believe that science and math were hard and that they weren’t important and nothing could be further from the truth. The BSA has always incorporated STEM components in their merit badges and advancement criteria, and the NOVA awards utilize those existing awards as well as some additional steps. **Science Everywhere** focuses on the scientific method and how science is responsible for nearly everything we have. All NOVA awards follow these basic requirements:

1. Research for an hour. It doesn’t matter how (reading, video, movie etc), but it should be specific to the subject.
2. Perform a group activity. For dens and patrols, this could be to earn one of the related rank’s elective Adventure loops or pin. Ones earned for another award cannot count. If an adventure loop is not an option, you can do an additional group activity of either a science experiment or orienteering.
3. Engage in a learning activity. This may have one or more facets, but is designed to involve the youth in research, critical reasoning, and presentation of their discoveries.
4. Visit somewhere where the subject in question is being used or performed.
5. Follow up with the NOVA counselor on what was learned.

I have incorporated a slideshow presentation and handouts for the youth that will cover every requirement of every question. For **Science Everywhere**, you will perform all of steps 1 and 2, 3, and one of the options in step 4. The following pages will help you to talk about the different subjects, provide questions that you can ask to get the youth thinking, and help to answer questions that may be asked.

NOVA awards, on average, should be accomplished in about a month’s timeframe. This gives the youth a chance to do their research, create their presentations, and discuss what they are learning along the way. Engage the youth in whatever activities you would like to in an environment that works for them, but they will learn best by doing. Follow the Leading EDGE and Teaching EDGE philosophies. I wish you the best of luck in your adventure.

Corey Peoples

Pack 455, NSC, C250-17-1

# Slide 1 - Beginning

Introduce yourself and the excitement with the youth. Why did you choose to lead this award? What’s your passion for science?

# Slide 2 - Agenda

Read verbatim or paraphrase:

The goal of this STEM course is to teach us how Science works and how it is in everything that we do. We will start off by selecting a book from the library, or watch a movie [akela, you decide]. Then there is an adventure loop that we will earn later for your rank. For number 3, we will get into the scientific method and all of the steps that help us to explain how things actually work. Next week, we will (Visit a location, explore a career) and through it all we will discuss what science means to us.

# Slide 3 – Learn for an Hour

There is an attached page in the Youth Worksheets document that covers the questions to follow up with reading. Be sure to print this out for each of the youth. Read verbatim or paraphrase:

Our first requirement is going to be to learn for an hour. I would like everyone to [Join me in watching a TV show or movie | Select a book from the library | select from some science Youtube videos]. During this learning process, I want you to tell me about what science you see and why the people doing the science do it.

# Slide 4 – Group Activity – Rank Adventure

For dens and patrols. Larger groups can move onto slides 5 or 6 instead of this step. Read verbatim or paraphrase:

We are also going to earn an adventure loop. There are a few to choose from, but the adventure loop we selected is \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ for you. That will be done (now, later, on another day, at home, etc). While we work on this adventure loop, I want you to keep in mind what science is being done in it. What things can you test, what observations can you make, and what can you report on.

# Slide 5 – Group Activity – Scientific Method

This is just an extension of what goes on in the NOVA award, with the added requirement that the scouts talk to a scientist. Any scientist will do. Read verbatim or paraphrase:

This NOVA course is all about science, so we are going to go through and learn the scientific method. For our group activity, we are going to do an extra experiment to count after we learn about the scientific method, and then we are going to talk to our guest \_\_\_\_\_\_\_\_, who is a \_\_\_\_\_\_ scientist, and find out what science they do and why they do it.

# Slide 6 – Group Activity – Orienteering

Orienteering adventures are a lot of fun, but they require quite a bit of prep work. Have an outdoor area that you can have the scouts use, have a map of the area ready, and have some landmarks and stops available to use. Compasses are also a requirement, as well as the tools needed to make one. I would highly recommend reading the guides on orienteering event setup prior to trying this at <http://orienteeringusa.org>. Read verbatim or paraphrase:

Our group activity today is going to involve maps and directions. This is a process called orienteering, and is often a skill that older scouts rely heavily on. For this, I have a map of the area showing where we are. Can anyone figure out how I have this map laid out? What landmarks or objects in the world can you see on the map? Ok, so if we can see the items on the map, and we lay the map down like this, then this map is positioned how we are currently standing. Cool, right? We now have our “bearings” or an understanding of where we are, but how do we go to what we want to go to? For that, we need to know what our destination is and we need to know how that relates to the word.

Who knows where North is? How can we find that out? Most maps have a cardinal drawn on them, that signifies what direction North is. We can also use a tool called a compass, which is a magnetic needle that has a line that always points to North. I have a few here we will use, but we are actually going to make a compass. This requires the following items: a magnet, a sewing needle, a cork cut in half, and a bowl of water. First, we have to Magnetize the needle, which means rubbing it against the magnet like we are honing a knife. We want to do this 10 to 20 times. What this does is creates a magnetic field on the iron in the needle. Now, using this pair of plyers, we can push the needle through the half a cork, which becomes our disk that allows the needle to float on water. Now put the cork and needle into the water in the middle. What happens to the needle? What direction is it pointing? What happens if you turn the bowl of water? Although this assembled compass wouldn’t be helpful on a hike, it goes to show that there are ways to make things, and this is the same principal that a purchased compass uses.

Now, let’s go on our orienteering hike, and using these compasses (purchased ones, not homemade ones), let’s find 3 spots for us to go. How this works is like this. We look at the direction we should go, so this map says <245> degrees. The dial turns and we can put <245> from the dial to the pointing arrow. Now we hold it flat in front of us and we slowly spin around until we put the red part of the compass needle inside the red arrow on the compass backpart. The phrase you will often hear is “Put red in the shed.” Now we walk in that direction until we are at our target. Although compasses have some wiggle room, we can get close enough to our target and correct as we need to. This is how explorers and navigators were able to direct themselves for thousands of years, before the invention of GPS.

# Slide 7 – Act Like a Scientist

Read verbatim or paraphrase:

Let’s get into our learning activity. Science is a structured way that we as humans can attempt to explain the world and universe around us. We do this by following a strict set of rules that says “We don’t know anything, but we can experiment to see if the world works like we see.”

# Slide 8 – Act Like a Scientist: Observation

Read verbatim or paraphrase:

It starts with an observation. Let’s say that I **observe** some trees are older than others. I can also observe that some trees are bigger than others. Observation is the first step.

# Slide 9 – Act Like a Scientist: Question

Read verbatim or paraphrase:

We see something in our world and then when I want to try to explain it, I can now ask **Questions** about the things I have observed. I can ask “does the width of trees have any connection to their age?” In science we don’t rule things out with just a quick yes or no, so how can I see if my question explains my observation?

# Slide 10 – Act Like a Scientist: Hypothesis

Read verbatim or paraphrase:

We come up with an educated guess, or **Hypothesis**. This is a statement that I want to test for, so my hypothesis is “I think wider trees are older and have had more time to grow more wood and bark.”

# Slide 11 – Act Like a Scientist: Experiment

Read verbatim or paraphrase:

Now I want to **Experiment** to see if my hypothesis holds true. What’s important when I do this is that I have to test over and over again, and make sure that my test setups are written down as well as the results.

# Slide 12 – Act Like a Scientist: Experiment (audio/video)

Play the video. Read verbatim or paraphrase:

Writing down your results is important because the goal of an experiment is to see if the hypothesis holds true. If it doesn’t, that’s just as useful as if it did. So for my tree experiment, I would want to measure the width of trees with consistent steps: Measure at 2 feet from the ground, use a fabric tape measure, only measure tress that you know the age of. There are other things that we call “variables,” or things that can change, that I could introduce too, such as different kinds of trees or measuring in different locations. The more variables that I have, though, the less accurate my data is. I want to test one variable and one variable only, so I need to make sure that I am measuring the same kind of tree.

# Slide 13 – Act Like a Scientist: Conclusions

Read verbatim or paraphrase:

Once the experiment is over, now we can look over all of the data that we collected and see if it supports or rejects our hypothesis. Either answer is useful because it helps us to explain our world better. In this case, looking at my tree measurements I can confirm that just because a tree is a certain width does not mean it is a certain age. My numbers don’t support my hypothesis, so I can reject it and move on to my next observation and question regarding the age of trees.

# Slide 14 – Act Like a Scientist: Report

Read verbatim or paraphrase:

Finally, what is important is the ability to report what you have found to other people. Other people are interested in the outcomes of your science experiments too, so letting them know whether your hypothesis is supported or rejected and how you came to that conclusion is going to help everyone. In Science, we use a process called Peer Review, meaning that once an experiment is completed, the scientist reports it to all of the other scientists in the world through journals. Other scientists can then perform the same experiments that was written in the journal. Other people can look at the data and say “That was a good experiment” or “there were too many variables and we can get a more accurate experiment by doing this instead.” Because it is being looked at by other scientists who want the truth and not someone who is trying to support a hypothesis that may not be correct, the peer review process is considered the standard for all science experiments.

# Slide 15 – Act Like a Scientist: Example Observation

Read verbatim or paraphrase:

Now, let’s look at the science process of something very familiar to all of us, thunder and lightning. We’ve known about thunder and lightning since humans have ever existed and it had always mystified us. We’ve **observed** this happening with our eyes and our ears. We also know the destruction it can cause. When lightning hits a building, the building starts on fire. When lightning hits a person or an animal, they are scorched and charred like overcooking a piece of meat. So when we **question** why lightning is here, what did we used to say?

# Slide 16 – Act Like a Scientist: Example Hypothesis

Read verbatim or paraphrase:

Every culture had their own explanation, their own **hypothesis**, for why lightning happens. For many ancient civilizations, they believed their strongest gods would use it as a weapon. If a culture didn’t have gods, they would explain it with animals. Many tribes in Africa believe that lightning is caused by a bird who can shoot it from it’s beak. Even Santa’s reindeer get in on the thunder and lightning lore, with Donner meaning thunder and Blitzen meaning lightning. You’ve probably even heard that thunder is just the sound of angels bowling. So when lightning strikes and we question why it does, old cultures would say “it happens because the gods want it to happen.” Can anyone guess what is wrong with this hypothesis from a scientific standpoint? We can’t experiment, can we? We can’t test this hypothesis at all, and so our Scientific Method circle falls apart. For thousands of years, this is where we stopped with our questioning.

# Slide 17 – Act Like a Scientist: Example Observation

Read verbatim or paraphrase:

Skip ahead to 1745. A new device was created called a Leyden jar. This jar is simply a glass bottle with water in it, and a metal pole from the top of the bottle to the water. Its purpose is to store static electricity, that spark you get when you shuffle your feet on the carpet and touch someone or something metal. It can hold a lot of charge and then zap whatever it needs to. It was the first type of battery ever created, but not a great battery. It lets all of its energy go at once, meaning it wouldn’t work well for a light bulb or refrigerator that needs a constant stream of electricity. Instead these were used in strange experiments like cooking a chicken or turkey. One thing that was **observed** with these battery discharges was the static shock looked similar to lightning, but much smaller and without the same loud deep crack of thunder.

# Slide 18 – Act Like a Scientist: Example Question

Read verbatim or paraphrase:

Along comes this man, Benjamin Franklin. After making a lot of money and selling his business, he became interested in science, and really with the Leyden jars. He asked questions like: Why does a chicken cooked with static electricity taste better than one cooked in the oven? And Why does the spark from when it discharges look similar to lightning?

# Slide 19 – Act Like a Scientist: Example Hypothesis

Read verbatim or paraphrase:

Building off of that, is it possible to capture a bolt of lightning? And that became his question he wanted to answer and the hypothesis that he came up with was “I believe that lightning is just a more powerful version of static electricity and therefore can be directed and contained.” At the time it was crazy, because the believed theory was one that satisfied many people’s explanations and could never be tested. Ben wanted to know because he wanted to find a way to use it to his advantage.

# Slide 20 – Act Like a Scientist: Example Experiment

Read verbatim or paraphrase:

So Benjamin came up with his famous kite experiment. He had two kites, one tethered to the metal of a Leyden jar and the other held with a key at the end of it. Flying in a fierce lightning storm, he was able to capture the lightning in the Leyden jar and discharge it with the key.

# Slide 21 – Act Like a Scientist: Example Conclusions

Read verbatim or paraphrase:

What he had done was shown the world that lightning is static electricity and must follow the same rules for electricity that they see everywhere: Metal conducts it, glass and rubber can insulate against it, and if there are multiple paths for an electrical shock to take, it will always take the one of least resistance. Benjamin was excited for this, because it meant that he could help to protect the nation he fought so hard for, the USA.

# Slide 22 – Act Like a Scientist: Example Report

Read verbatim or paraphrase:

After confirming that Lightning was electricity, he told his friends in the US and France what he had learned and he came up with a new device that could prevent lightning from burning down buildings by capturing the shock and running it safely to the ground. We call these Lightning Rods. The design is simple, just a piece of metal that is taller than the building it is attached to. The rod is then connected to wire that runs down to the ground and allows for a safe discharge. The lightning will hit this rod before the building because it is less resistant than wood or stone, and then prevent the building from catching on fire. This is widely used today for many buildings and monuments. Imagine what life would be like today if we were still afraid of lightning and struggled to understand it. Science allows us to take something mysterious and understand how it works. So with that in mind, let’s look at some science experiments we can do

Akela, the next few slides are some quick science projects appropriate for youth. Select the one(s) you wish to do with the children and have fun. Try to explain why the experiments are doing what they are doing, and have the youth participate in as much as they can. Don’t forget to talk about the different types of typical sciences (physics, chemistry, biology) as well as the more modern sciences (psychology, sociology, economics). Make it a point to show that science drives everything we do. If the group is older, you can also talk about the dangers of pseudoscience and how people might be trying to convince you something is not the way it is, either by manipulating the experiment or manipulating the data. These are usually done for personal gains and that is why peer review is crucial.

There is also an attached worksheet in the Youth Worksheets document to cover the different steps in a science experiment.

# Slide 23 – Act Like a Scientist: Experiment

Coca Cola has a pH of 2.5 meaning it is extremely acitic. It will clean rust, metal, etc quickly. Dissolve a nail or a penny in about a week, clean a penny in about 24 hours. What other metals would this work with? What metals wouldn’t it work with? How can you test and what is your control

# Slide 24 – Act Like a Scientist: Experiment

Egg shells are not very smooth, so it is possible for dyes to get into eggs. Acid eats away at the shells which can allow for more dye to soak. That’s why we color eggs with vinegar for easter. Take some different pops and soak eggs in them for a period of time. What happens to the eggs? Have the youth come up with some different liquids they might want to try and how they can tell whether there is acid in something or not.

# Slide 25 – Act Like a Scientist: Experiment

The Low-Flow volcano is a neat one because it is not something that youth have really heard of, but it makes perfect sense when you look at the ingredients of ketchup. If you put ketchup into a container and put baking soda on top of it, not much will happen. You will have to stir the baking soda into the ketchup and then watch. Ketchup has Vinegar as one of its ingredients, so it will create the bubbles we are familiar with. Use this as an example for the youth to tell them why sometimes it can be difficult to do an experiment with so many variables, and that if you wanted to figure out which ingredient was responsible for the bubbling portion of the volcano then you have to test each one individually.

# Slide 26 – Act Like a Scientist: Experiment

The Medium-Flow volcano is a common one because it is easy to do and safe. Take Vinegar and put baking soda in it. The liquid will absorb the powder, and as they chemically react then it will create a byproduct of carbon dioxide. That is the bubbles that we see, the same bubbles in our pops that we drink. Ask the youth about why this is happening, and what they could change in a similar experiment (more or less vinegar, different powders or liquids, size and shape of magma container, etc). Stress that science is about understanding, not just proving. Understanding why these chemicals react helps to figure out more about the makeup of the experiment.

# Slide 27 – Act Like a Scientist: Experiment

The High-Flow volcano another common one for people to know about, because thanks Internet. Drop several Mentos into diet coke and stand back. As the two combine, they create a lot of carbon dioxide and it creates a significant plume of bubbly diet coke. For this experiment, I would suggest doing it outside or having a tarp. For similar experiments to understand the reaction better, what other things can be mixed to create similar reactions. The Myth Busters show did a great expose on this reaction that I would suggest watching.

# Slide 28 – Act Like a Scientist: Experiment

There are 2 options here: coca cola + milk will curdle and take away the color (don’t drink it unless you want an awful taste in your mouth). Coca cola + bleach will quickly take away the color (also don’t drink, but I hope that is apparent). Tests could include: how much of each is needed? What are the effects of different amounts? What other chemicals might do this? How can you test a control? Would this effect work with other pops too?

Other experiments

It’s Bigger on the Inside:

With a hardboiled egg and a glass bottle with a mouth about the size of an egg, just a bit smaller, light some papers and quickly put them in the bottle, then put the egg on top. After they go out it should create a vaccum that sucks the egg in. Explain how this works without breaking the egg, why a glass bottle is important, and what else might be able to do this (bouncy balls, tennis balls, chocolate bars. How would you get a control variable in your experiments?

Transparent eggs:

This requires more time. Submerge an egg in vinegar for 24 hours and the shell will dissolve. Why is this, what else could do this, how would you set up a control variable?

The temperature of Light

Is some light warmer than others? We’ve described red colors as warm and blue as cool, but do those stem from actual testing? It does! Have sunlight go through a prism so it splits into a rainbow, and take different measurements along the rainbow. What you will find is blue light is cooler than red light. You can also talk to the youth about control variables here, and put another thermometer outside of the sunlight to measure the air temperature, too. This experiment was actually how infrared light was found, because William Herschel set his control just outside of the rainbow’s red light and found it was hotter than the red and blue lights.

Nature vs Nurture

For a longer-running experiment, plant some seeds. Do different tests, give one water and light, give different ones different amounts of light and water and see how they grow. Use your scientific reasoning to analyze the output of your data. To reduce variables, make sure that they are all the same plant and all have the same dirt to grow in.

# Slide 29 – Act Like a Scientist: Recap

This is just a recap slide. Feel free to quiz people on the different parts of the scientific method, and have the youth come up with their own experiments.

# Slide 30 – Visit Where Science is Being Done

Science Everywhere only has an option for number 4 to visit, which is easy as science is done everywhere. Print out the visitation page from the youth worksheets document for each of the youth in attendance. Read verbatim or paraphrase.

Now, lets’ talk about our field trip. We are going to go to \_\_\_\_\_\_\_\_\_\_\_\_ and look at the science that they do.

# Slide 31 – Visit Where Science is Being Done

If you need additional ideas of where to go for science, these places are common and usually offer free tours. Simply give the closest one to you a call.

# Slide 32 – Discuss what you have learned

Now is the time to wrap up. What did the scouts learn in this adventure? What was fun for them? Can they list off all of many of the components of the scientific method?

# Final Thoughts

Akela,

Thank you so much for running this. I hope that you have had as much fun as the youth. Be sure to turn in whatever documentation is required to your advancement chair so that the youth earn both their NOVA award and their adventure rank.